Cost analysis of treating Cholera patient in Tanzania: a Public health care system Perspective

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DEDICATION

I would like to full dedicate this study to my beloved wife, Mwajuma and our sons Qadir Hamad Nyembea, Basaaria Hamad Nyembea and Darius Hamad Nyembea in recognition of their marvelous and tireless continuous heartfelt support for my whole stay in South Korea when undertaking my Master's degree program.

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GLOSSARY

Choltool	Cholera too data software
DHIS2	District Health information System 2
HMIS	Management information System
IDSR	Integrated Disease Surveillance and Response
IVI	International Vaccine institute
MSD	Medical Store Department
ORS	Oral Rehydration Solution
SFR	Sensitivity Factor ratio
TZS	Tanzania Shilling
UNICEF	United Nations International Children's emergency Fund
WASH	Water access, Sanitation and Hygiene
WHO	World Health Organization

ABSTRACT

Background: Cholera disease remains a global public health concern mostly in Lower and Middle income economies. Data on disease burden to the public health system for the policy decision makers to use are in adequate in Tanzania. This study aims to estimate the direct economic burden of Cholera disease in the Public health system.

Methods: This is a retrospective study involving data of four years from 2015 to 2018 from the Health management information system (HMIS) database from MOH Tanzania, Health facility registry, Ministry of Public service and good governance, MSD Tanzania, UNICEF, Previous publications and WHO. Data collected from the facility were entered to costing tool called "Choltool" to estimate the cost incurred by the facility to manage Cholera outbreak and cost to treat a single Cholera patient. Data from previous publication provided ranges of Cholera cases as minimum and maximum which were intertwined with data from MOH by using special equation to get average ranges of Cholera cases for each year. These cases were multiplied by cost to treat single patient to get sensitivity cost ranges in each year for the study years.

Results: In this study we found that, on average, the treatment cost of Cholera patient was estimated to be US$ 106.75. Furthermore, the average annual Cholera treatment ranged from US$ 3.24 million in 2015 to US$ 1.18 Million. In this study, we also found that facility support and supplies is the major driver for the treatment cost and constituted almost 34.0% (US$ 36.32) of all costs incurred.

Conclusion: This study revealed the economic burden of cholera to public health care system in Tanzania to be as high as US$ 106.75. Altogether, our findings have direct policy implications regarding investments in prevention of cholera. Future similar study economic burden of Cholera study involving both direct and indirect cost needed to deepen understanding.

INTRODUCTION

Cholera as a diarrheal disease is still a global public health concern skewed mostly to Lower and Middle income economies. In the year 2017 alone, more than 1,227,391 Cholera cases and 5,654 Cholera deaths were reported to World Health Organization (WHO) by 71 countries, Africa attributed 14.7% of the cases and sub Saharan Africa accounted for the 49.1% of all Africa reported cases (World Health Organization, 2018). However, under reporting of Cholera cases and deaths to World Health Organization (WHO) by many countries in the world including Tanzania also remains as a big challenge to ascertain the magnitude of the problem. The reasons for under reporting in many countries including Tanzania are inadequacy of surveillance systems, weak diagnostic capacities and the fear of socio economic and political consequences (World Health Organization, 2000).

Recent study by Vital Mosagale et al in Asian countries reported that the estimated economic burden of cholera illness in Asia is $41 million (95% CI: $26.5 million to $65.9 million) and about $29 million (70.73%) is due to direct costs borne by the health system and individual family members (Vittal Mogasale, Vijayalaxmi V Mogasale, & Hsiao, 2017). Another similar study conducted in Malawi by Ilboudo PG et al demonstrated a huge burden of Cholera cost in health facilities estimated to USD 59.7 per Cholera patient treatment (P. G. Ilboudo et al., 2017).

Tanzania being among the Sub Saharan Africa, Cholera remains to be a problem of public health significance and therefore putting a society at high risk of Cholera outbreaks and negatively impact socio economic activities. There are only few number of surveillance

studies conducted previously in Africa and Tanzania in particular on the economic burden of Cholera, however, the estimates of the burden of Cholera disease in the studies mentioned above were done by using modeling approaches.

Cholera global burden study estimated that there are 2.86 million (uncertainty Range: 1.3M - 4.0M) Cholera cases and 95,000 deaths (Uncertainty Range: 21,000-143,000) annually in Cholera endemic countries, Tanzania included (Ali, R Nelson, Lopez, & Sack, 2015). Of 1,227,391 of all WHO reported Cholera cases globally in 2017, 14.7% of the share of this burden of Cholera cases are reported from Africa in which case Sub Saharan Africa contribute 49.1% of all cases, Tanzania being among Sub Saharan Africa has a share of 5.5% of all Cholera cases (World Health Organization, 2018). Another study conducted by Mohammed Ali et al showed that the estimated number of Cholera cases in Tanzania ranges from 80,952 to 84,550 in 2015 (Ali et al., 2015).

In Tanzania about 48% (Veronicaa M. Mpazi & Mnyika, 2008) of all admissions in the country due to notifiable diseases among patients aged 5 years and above were due to cholera cases in the year 1997. About 57% of deaths due to notifiable diseases for 5 years old and above patients were cholera cases (Veronicaa M. Mpazi & Mnyika, 2008). For many years Tanzania has been a Cholera endemic country which reports cases to World Health Organization (WHO) annually (Poulos et al., 2012). Many factors such as shortage of clean water, improper waste disposal, poor food handling, processing, and preservation, poor housing, improper and lack of basic sanitation systems place people at a greater risk of being infected with cholera and other diarrheal diseases. The most affected families are

those unable to access clean and safe water, poor families and mostly the rural and urban families in suburbs lacking basic sanitation facilities (Veronicaa M. Mpazi & Mnyika, 2008).

Geographical, socio-economic and socio cultural backgrounds of people in the affected area which influence practices may also contribute to spread of cholera. These include low educational level, unhygienic food handling practices, poor use of latrines, poor disposal of excreta and proximity to surface water. This is because the bacteria (Vibrio cholerae) that cause cholera are known to be normal inhabitants of surface water (Veronicaa M. Mpazi & Mnyika, 2008).

In Tanzania, cholera outbreaks had been occurring every year since 1977, when the first person believed to have been affected by the disease was first reported (Acosta CJ et al., 2001). Tanzania was found to have the highest number of cases in Africa in 1997 (40,249) and 1998 (43,000) compared to Guinea Bissau (20,555), Kenya (17,200), Chad (8,801) and Mozambique (8,708) in 1997 and Kenya (18,000), Uganda (18,000) and Somalia (14,708) in 1998 (10). Tanzania had one of the highest case fatality rates in East Africa with 2,268 deaths out of 40,226 cases (Crescent, 2007).

Tanzania has been embarking much efforts in the investment of curative health services in the public health Care system and preventive control strategies which are key to controlling infectious diseases had been allocated very little share in the nation health budget (UNICEF, 2018) (Tarimo, 2018) and therefore making fight against Cholera disease difficult and ultimately making the country a hub for Cholera disease outbreak annually.

To have a full insight of the broader economic impacts of Cholera on the Public health care system, the costs of illness incurred by the health care facilities have to be assessed and aggregated country wide. The information on the economic burden of Cholera which will be obtained from this study is of paramount importance for the government in conducting economic evaluations and making decision on Cholera control strategies such as clean water availability and access, basic sanitation and Hygiene (WASH) Strategy. The implementation of WASH strategy by the government will offset the cost incurred for treatment of Cholera cases, prevent morbidity and mortalities caused by the disease.

Moreover, information on economic burden of Cholera will serve as advocacy tools to policy decision makers in demonstrating how important WASH strategy is more cost effective preventive measure compared to curative strategies. The implementation of WASH strategy and the use of Cholera vaccine in high prone Cholera areas (Cholera hotspots) will pave the way to eradication of Cholera and other diarrheal diseases in the country and subsequent create better environment for the development of the country.

Goal and Objectives of the study

Goal

This study aimed to estimate the direct economic burden of Cholera to the public health care system for the purpose of creating awareness to policy makers for possible subsequent paradigm change in strategies on prevention and control of Cholera and other related diarrheal diseases.

Objectives

This study will answer the following objectives:

- To estimate direct economic costs incurred by public health system to treat a Cholera patient.
- To estimate direct economic costs incurred by public health facility to manage Cholera outbreak.
- To estimate direct economic costs incurred by the country's public health care system from 2015 to 2018.

METHODOLOGY

Description of the study setting and Cholera Outbreak

Cholera outbreak occurred in 2018 in Kimamba ward which comprises 8 villages and it has an area of 29 Km^2 and a population of 12,046 with 5,835 Male, 6,211 Women, and 1,663 Children under 5 years, 3,796 Children aged 5 to 14 years and 6,587 aged above 15 years old. This is a rural area and has one health centre (Kimamba health centre) which is serves the whole population and basic primary health care services are delivered. This facility had a total of 42 health personnel which were involved in the management of the outbreak. Community obtain water supply for domestic consumption through mostly temporary underground shallow wells and majority of household neither boil nor treat drinking water. Access to basic water in Kimamba ward is around 37% according to information from the District medical officer office. Most of households used pit latrine as means of fecal disposal and about 23% of the households have pit latrines with slab floor (Minitry of Health and Soical Welfare, 2011).

The outbreak in 2018 in Kimamba ward occurred during rainy season (January to April) as the result of resumption of temporary wells which formed due to rain water collection. This outbreak was reported by Kimamba health centre which was the used as the Cholera treatment centre to manage the outbreak. The outbreak affected 72 people (43 Male and 29 Female) which resulted into three deaths.

Data sources

The data on the number of cases of Cholera reported for four years to the Ministry of Health- Tanzania in 2015, 2016, 2017 and 2018 were requested and retrieved from the Ministry of Health's Management information System (HMIS) database (CHILDREN, 2019). In Tanzania, infectious diseases including Cholera are reported under Integrated Disease Surveillance and Response (IDSR) as weekly epidemiological records and annually aggregated to obtain a nation annual summary cholera report. Furthermore, aggregated annual cholera data from the Ministry of Health were referenced to WHO cholera report for 2018 (World Health Organization, 2018) to ascertain its correctness. To narrow down to get the cost incurred by public health facility, data for Cholera cases were collected from one of the District (Kilosa District) in Tanzania where outbreak occurred, these data were retrieved from 2018 Kimamba health center registry and were compared to the District Health information system 2 (DHIS2) (CHILDREN, 2019). Prices for drugs and medical supplies will be obtained from Medical store department (MSD) catalogue for 2018 (Tanzania, 2018) and for items which are not available in Tanzania MSD price catalogue will be obtained from UNICEF supply catalogue (UNICEF, 2019). The prices for building equipment and structural materials were requested from the district Medical Officer to get the local prices for materials used for setting up tents for Cholera treatment center. To avoid underestimation and overestimation of Cholera cases and therefore the cost incurred in treatment, we used conservative sensitivity ranges of Cholera cases reported in other study conducted by Mohammad Ali et al (Ali et al., 2015). The unit costs of the hotel components

of service delivery such as Manpower (Salaries and allowances) were requested and obtained from Tanzanian Ministry of President's Office-Public servant Management where circulars used for manpower salaries and allowances were given. World Health Organization (WHO) treatment guideline (World Health Organization, 2015) will be used to provide standard treatment for mild/moderate and severe cholera. Currency exchange rate used was collected from Google currency converter (Converter, 2019). The table 1 below summarizes expenditure variables of the study and sources of data for health system.

Table 1: Expenditure components of variables and sources for health system.

Cost component	**Description of costs**	**Source**
Staff incentives	Salaries, Perdiems, Standard meal allowance, Extra duty allowances, Transport fares	President's Office - Public Service Management and Good Governance. (Circular Ref No AC.128/260/01 Revision of Salaries in the Civil Service 12th October, 2009.)
Drugs and Medical supplies	Zinc sulphate, Sodium Lactate infusion, ORS, Infusion giving set, Needle, Scalp vein, Tourniquet, latex, Tube feeding, Feces Collection container, Erythromycin powder, Doxycycline caps, Container Sample, Ciprofloxacin caps 500 mg, Cannula (16G,18G,22G) Razor, Safety, single use PAC, Paracetamol tablets, Thermometer Tray, dressing.	Tanzania MSD price catalogue 2018-2019 final.

Cost component	Description of costs	Source
Facility Support supplies	Water purification tablets, Safety boxes for used syringes, Povidone soln 10% BOT/200ml, Polyvidone Iodine 10% BOT/500ml, Medical tape Gloves, Mop with hand, Drum for Chlorine soln, Chlorine 40 mg for 10L water, IEC material (Flipchart), Chlorine test tables DPD3, Bag, biohazard, Chlorine test tablets DPD1	UNICEF Supply Catalog (accessed July 2019)
	Cup plastic 500ml, Bucket, HDPE 20L with Lid Bucket, HDPE 14L with lid Bucket, plastic 14L with clip cover, Water tank kit, OXFAM type 5000L, Note book, Rake, Spade and Pick Axe	Dr Halima Mohamed, Kilosa district Medical Officer.
	Cotton Wool, Gauze, Body bag (PIC) Boots, rubber (PVC), reusable (size 42, 43, 44),Basin for water collection Bucket, HDPE 5L, Apron, disp(PAC), Plastic dustbin with cover, Stand for hand washing, Chlorine ½ container, Blanket	Tanzania MSD price catalogue 2018-2019 final.
Other costs	Fuel for ambulance Burial Costs	Dr Halima Mohamed, Kilosa district Medical Officer.
Equipment and structures	Tents (small, medium and Large), Pit latrine Washing rooms	Dr Halima Mohamed, Kilosa district Medical Officer.
	Glucometer, Stethoscope, Weigh Scale (Child and Adult) and Sphygmomanometer (adult and Child).	Tanzania MSD price catalogue 2018-2019 final.
	Plastic Mat	UNICEF Supply Catalog (accessed July 2019)

Year Selection

Because of the cholera endemicity in the country, four years under study will be from 2015 to 2018. The selection of more recent years based on the fact that the study result will provide a close to reality picture of estimation economic burden of Cholera in the public health system.

Data Management and analysis tool

The study used a Cholera tool software called "Choltool" which is a standardized Microsoft excel-based for cholera cost analysis. This is Cholera cost analysis calculator developed by International Vaccine institute (IVI), WHO and DOVE (International Vaccine Institute, 2018). This tool however uses health system economic perspective of treatment costing where individual household direct and indirect costs are not included. All costs for medical supplies, medicine and manpower capital will be entered in the "Choltool**"** for analysis. This tool has costs divided into two categories financial and economic costs. Financial costs are the explicit costs which are typically reported in standard accounting reports and are the direct expenditures which outlays for the previous year same outbreak management while economic costs are financial costs (explicit costs) plus monetized valuation of all inputs needed for the treatment of Cholera patients including valuation of time, supplies, equipment and annualization of costs that adjusts for a discount rate (Logan Brenzel, 2013) (Patrick G. Ilboudo & Le Gargasson, 2017).

This Choltool is in a series of worksheets in a single workbook and it has interlinked modules which contain input, output, dashboard, variable selection, assumption and formulas to produce outputs.

Variables used for Cost estimation

We used a special costing tool called "Choltool" to analyze data to get the average cost estimation for the treatment of Cholera patient. Following below are the variables which were selected in this study,

Direct Costs for drugs and medical supplies

This represents the sum total of all costs incurred by the public health care system in for the use of drugs and medical supplies in treating Cholera patients. For drugs, these include those which are used to treat all Choler and all forms of diarrhea which are daily dosage of ORS, antibiotics, intravenous fluids and Zinc for Children. For patients with severe Cholera, the product of dosage of Doxycycline and Ringer Lactate (Hartmann's solution), number of times a dosage of Tetracycline is taken per day, price per unit of Tetracycline and the number of patients with severe Cholera Medical supplies include gloves, cannula and all other non-medicine items. This costs are reflected as economic costs. Number of doses and the medical supplies used treating each patient are multiplied with the price of each item to get the cost incurred for this variable. Table 2 depicts WHO cholera standard treatment guideline (World Health Organization, 2016).

Table 2" Standard treatment regimens for Cholera cases.

Antibiotics	Dose	Children			Adult (= >15 years)	Pregnant women
		Under 1 year	1-4 years	5-14 years		
Erythromycin 250 mg	30mg/kg qid x 3/7	125mg OD x3/7	125mg qid x3/7	250mg qid x3/7	500mg qid x3/7	500mg qid x 3/7
Doxycycline	300mg stat				300mg stat	
Ringer Lactate Solution (IV) in Liters (L)	1L OD x 3/7	1L OD x 3/7	1L OD x 3/7	1L OD x3/7	1L OD x3/7	1L OD x3/7

Qid- four times per day, OD- Once per day, 3/7- three days of a week.

Source: Current WHO 2011 Guideline for Cholera treatment

Personnel costs for Salary Payment, travel and allowances

This includes costs for public health facility for personnel monthly salaries and allowances for extra duty and transport for personnel. The salary of each personnel cadre was multiplied by the number of health personnel in the facility to get the total economic cost incurred in a Cholera treatment center. Because Cholera outbreak is a Public health emergency and mitigation for response is implemented by government, health personnel work in extra hours and they are paid extra duties in which standardized allowance is computed by the "Choltool" to yield costs incurred and because these costs are paid due extra duty work because of Cholera episodes then this is financial costs.

Facility treatment support supplies

This variable includes the costs incurred by the public health care system for items used to enhance infection prevention and control such as Chlorine for cleaning, biohazards safety boxes and material for health communication and education to the community such as IEC materials, stationaries etc.

Other Costs

These include costs incurred by the public health care system for burial of deceased cholera patient which for the purpose of controlling further spread of Cholera the government took the responsibilities of burial of deceased ones with collaboration with the families of the deceased. Other costs in this category is the fuel for ambulance services which was used during emergency needs.

Equipment

This variable includes the costs of all medical equipment which are used in health facility for treatment, examples includes hospital beds, glucometer, basins, BP machine etc.

Structures

This category of variable include any physical construction done during Cholera outbreak which necessitated treatment of Cholera. This includes tents, buildings for patient wards and latrines.

Average Cost estimation Modeling

A. Real public health facility cost estimation

We used the costing tool "Choltool" as a software to manage our data. "Choltool" developed by International vaccine institute, WHO and DOVE (Tembo et al., 2019). All data collected from the public health facility were entered into the "Choltool", verified and computed automatically to yield output for each variable. The total cost incurred by one public health facility which managed the outbreak of Cholera disease during the outbreak was found. Furthermore, the "Choltool" calculated the average cost incurred to treat one Cholera patient.

B. Cost estimation for the whole country

To extrapolate and obtain the total average cost estimation incurred by the whole country we used three sources of data for comparison and applied some modeling to get data for four years from 2015 to 2018. The data for Cholera cases for the whole country were uncertain because data reported in the Ministry of health Tanzania had minor discrepancies with those reported in WHO (Table 5). The much concern that we noted is about under reporting of cases after comparing data from the Ministry of Health Tanzania and data from a published study on the updated Cholera cases by Mohammad Ali et al which showed a myriad differences. Cholera Cases Sensitivity ranges were estimated based on Population at risk and incidence rate from a study conducted by Mohammad Ali et al (Ali et al., 2015). Our study aim at estimating economic burden of Cholera to the country's Public health care

system and because data for Cholera cases are uncertain, we linked Cholera data cases from the Ministry of Health and retrieved published updated Cholera cases from study by Mohammad Al et al to establish a range of Cholera cases as minimum and maximum cases. To get this Cholera case range we used Conservative sensitivity ranges published by Mohammad Ali et al which was a one year study as a baseline and extrapolated for the four years from 2015 to 2018. According to Mohammad Ali et al published Cholera data, Conservative sensitivity Range one (S1) was estimated based on population at risk based on percentage without sustainable access to improved water and conservative sensitivity two (S2) cases was estimated based on the 50% of the incidence rate estimate.

However, since Cholera sensitivity cases retrieved from the published updated Cholera cases study by Mohammad Ali et al. were for one year, therefore to estimate the sensitivity ranges for our study years we used Sensitivity factor ratios (SFRs) for conservative Sensitivity one (S1) and Sensitivity two (S2) to get the Sensitivity case ranges. Sensitivity factor ratio (SFR) is defined as the constant obtained by taking the ratio of sensitivity one and two. Sensitivity ratio factor one (SRF1) is the product of Cholera sensitivity one (S1) cases retrieved from the study divide by total of Sensitivity one (S1) and sensitivity two (S2). Similarly, Sensitivity ratio factor two (SRF2) is the product of Cholera Sensitivity two (S2) cases retrieved from the study divide by sum of Sensitivity one (S1) and sensitivity two (S2).

Formula:

$$SFR1 = \frac{S1}{S1 + S2}$$

$$SFR2 = \frac{S2}{S1 + S2}$$

Where,

SFR1 is Sensitivity factor Ratio one

SFR2 is Sensitivity factor Ratio two

S1 is maximum conservative Sensitivity one from a previous study publication.

S2 is Minimum conservative Sensitivity two from a previous study publication.

These sensitivity factor ratios (SFRs) as constants were then used for calculation of each year's estimated number of Cholera cases from 2015 to 2018. To further minimize the effect of under reporting or over reporting of Cholera cases, we used the number of Cholera cases reported in the Ministry of Health as integral part of the equation used to estimate Cholera cases for each respective study year. The ratio of Cholera cases for each study year was multiplied to the total conservative Sensitivity ranges one and two (S1 and S2). To get estimated Cholera cases for each respective year then Sensitivity factor ratio one (SFR1) was multiplied by reported Cholera cases to MOH to get the maximum estimated Cholera

cases, Similarly, Sensitivity factor ratio two (SFR2) was multiplied by reported Cholera cases to MOH to get Minimum estimated Cholera in each respective year. The integral equation for estimation of Cholera cases is as follows,

$$Xi = \left[\left(\frac{ni}{N}\right)(S1 + s2)\right] SFR$$

Where,

Xi is the estimated Cholera Cases in a respective year.

ni is the number of Cholera cases reported to MOH in a particular year.

N is total number of reported cases for four study years.

SFR is the Sensitivity Factor ratio, Constant.

S1 is maximum Conservative Sensitivity range

S2 is minimum conservative sensitivity range.

Table 3: Estimated Sensitivity Ranges for Cholera cases from 2015 to 2018.

Year	Cases reported in MOH	Sensitivity 1 (Conservative).	Sensitivity 2 (Conservative)
2015	12,118	31,665	29,129
2016	11,360	29,684	27,275
2017	4,636	12,105	11,131
2018	4,414	11,525	10,598
Total	**32,528**	**84,937**	**78,100**

Unit of costs

We used an estimation in United States Dollars (US$) 2018) and Tanzanian Shilling (TZS).The costs to be reported are converted to 2018 US$ to reflect the actual costs incurred.

Ethics statement

This study followed protocol set by Yonsei University Postgraduate school of Public Health Research Ethics Committee. Permission to get data from the Ministry of Health Tanzania and from the public health facility in Kilosa district was given by the Ministry

of Health Tanzania. Fidelity form for ethical conduct from Yonsei Postgraduate School of Public Health Research Ethics Committee was signed.

RESULTS

Average Cholera treatment cost for one sampled public health facility.

Table 4 shows the average cost per health facility for treating a cholera patient, the distribution of costs as operational and capital costs. On average, the treatment cost incurred per public health facility was US$ 7,686.24 which is sum total of financial and economic costs of both operational and capital costs. Operational costs accounts for almost 92.06% (US$ 7,075.64) of all costs incurred by the health facility and the remaining (7.94%) costs are due to capital costs. Moreover, we found that facility support supplies account for almost 34.1% (US$ 2,615.58) of the cost incurred by the health facility, other costs in the health facility came as the second most important driver accounting for 21.8% (US$ 1,676.10) of incurred costs, travel and allowances by 20.9% (US$ 1,602.08). We are not surprised that drugs and medical supplies were the smallest driver, accounting for about 10.5% (US$ 807.78) incurred by the health facility for treating the disease, this is because treatment in all cases is mostly rehydration and single antibiotic and also shorter hospital stay (3-4 days). Other drivers for the treatment costs are structures which account for 7.6% (US$ 580.46) and personnel which account for 4.9% (US$ 374.10). This study also found that, for the costs incurred by the health facility in the treatment of Cholera patient, economic costs account for almost 52.4% (US$ 4,025.16) whereby financial costs account for 47.6% (US$ 3,651.06).

Table 4: Cholera treatment cost per public health facility.

		Financial (USD)	Economic (USD)
Operational Costs	Salaries	0.00	374.10
	Travel & Allowances	801.04	801.04
	Drugs and Medical Supplies	403.89	403.89
	Facility Support Supplies	1307.79	1307.79
	Other Costs	838.05	838.05
	Total Costs (Operational)	3350.77	3724.87
Capital Costs (Annualized) (only in months when facility is in operation)	Equipment	10.05	10.81
	Structures	290.23	299.49
	Total Costs (Capital)	300.29	310.31
Average Cost per Facility		3651.06	4035.18

Estimated Cholera treatment cost incurred per single Cholera patient

Table 5 depicts the treatment costs incurred per patient, recurring and capital costs. In this study we found that the average cost incurred in the treatment per patient is US$ 106.75 which is the sum total of financial and economic costs of both operational and capital costs. Operational costs account for 92.1 % (US$ 98.27) of all cost whereby capital costs contribute for 7.9 % (US$ 8.48). Moreover, we found that economic costs account for almost 52.2 % (US$ 55.75) of the treatment costs while financial costs account for 47.8% (US$ 50.41). In average costs per patient, we found that facility support supplies accounted for 34.0% (US$ 36.32) of all costs incurred per patient followed by other direct costs by 21.8% (US$

23.26) and then travel & allowances by 20.9% (US$ 22.26). Personnel accounts only for 4.9% (US$ 5.20) of the total operational cost per patient. In the capital costs, Structures contributed almost 7.7 % (US$ 8.19) of the cost incurred per patient.

Table 5: Average Cost per treatment of one Cholera patient**.**

		Financial (USD)	Economic (USD)
Operational costs	Salaries	0.00	5.20
	Travel & Allowances	11.13	11.13
	Drugs and Medical Supplies	5.61	5.61
	Facility Support Supplies	18.16	18.16
	Other Costs	11.64	11.64
	Total Costs (Operational)	46.54	51.73
Capital Costs (Annual-ized)	Equipment	0.14	0.15
	Structures	4.03	4.16
	Total Costs (Capital)	4.17	4.31

Estimated Cholera treatment cost annually for four years incurred by Public health care system

Table 6 depicts the estimated annual Cholera treatment costs incurred by the public health care system from 2015 to 2018. Our study found that annually, public health care system incurred an estimated cost ranges from US$ 3,244,879.75 (Sensitivity Cost range: US$ 3,109,520.75- US$ 3,380,238.75), US$ 3,040,186.62 (Sensitivity Cost range: US$

2,911,606.25 - US$ 3,168,767.00), US$ 1,240,221.50 (Sensitivity Cost range: US$ 1,188,234.25- US$ 1,292,208.75) and US$ 1,180,815.12 (Sensitivity Cost range: US$ 1,131,336.50- US$ 1,230,293.75) in 2015, 2016, 2017 and 2018 respectively. Moreover, we found that the estimated total Cholera cases treatment costs incurred by the public health care for the period of four years from 2015 to 2018 is amounting US$ 8,702,099.87 (Sensitivity cost range: US$ 8,337,175.00 to US$ 9,067,024.75).

Table 6: Estimated Cholera treatment Cost by year**.**

Year	Cases reported to MOH	Cases reported to WHO	Cases based on Sensitivity 1 (Conservative)	Maximum cost sensitivity 1 incurred annually (US$)	Cases based on Sensitivity 2 (Conservative)	Minimum cost sensitivity 2 incurred annually (US$).	Estimated average cost Sensitivity.
2015	12,118	11,563	31,665	3,380,238.75	29,129	3,109,520.75	3,244,879.75
2016	11,360	11,360	29,684	3,168,767.00	27,275	2,911,606.25	3,040,186.62
2017	4,636	4,895	12,105	1,292,208.75	11,131	1,188,234.25	1,240,221.50
2018	4,414	4,389	11,525	1,230,293.75	10,598	1,131,336.50	1,180,815.12
Total	**32,528**	**32,207**	**84,937**	**9,067,024.75**	**78,100**	**8,337,175.00**	**8,702,099.87**

Figure 1 shows the trend of Cholera treatment costs incurred by the Public health care system for four years. The study found that Cholera treatment costs incurred by Public health care system for 2016 and 2017 were slightly similar at an average cost of US$ 3,244,879.75, US$ 3,040,186.62, US$ 1,240,221.50 and US$ 1,180,815.12 for 2015, 2016,

2017 and 2018 respectively. Moreover, Cholera treatment costs for the past latest years that is 2017 and 2018 had not changed much as trend is fairly the same.

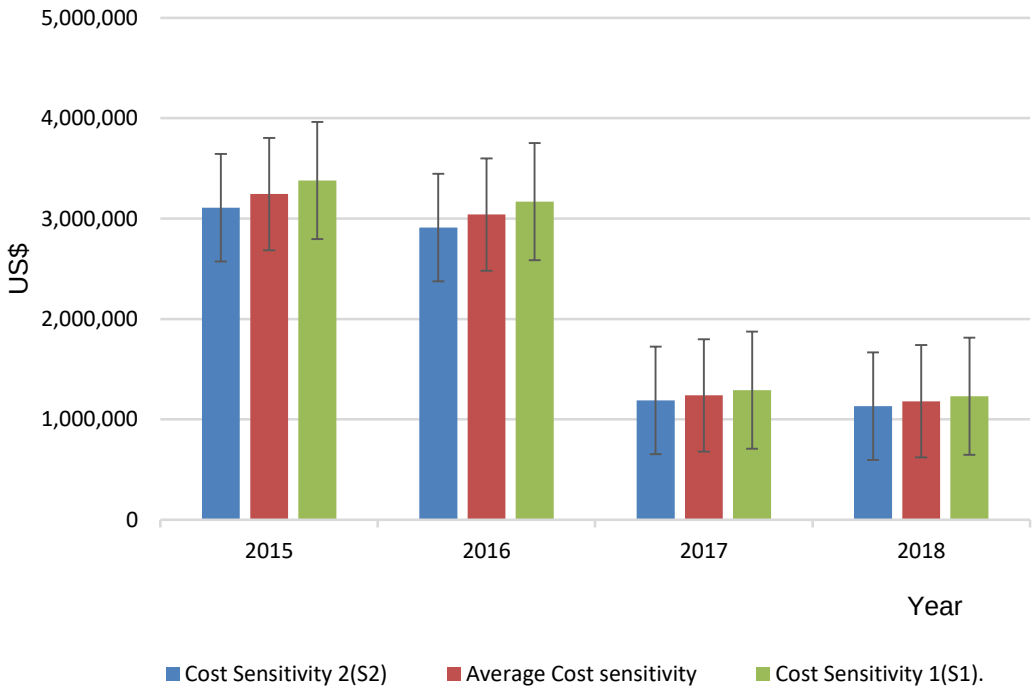

Figure 1: Trend of Cholera treatment costs to public health care system for four years.

Figure 2 depicts average estimated costs incurred in each year in each variable cost. The figure shows that facility support supplies cost significantly than all other item costs in each year US$ 1,104,019, US$ 1,034,375, US$ 421,965 and US$ 401,754 for 2015, 2016, 2017 and 2018 respectively. This is followed by other direct costs, travel and allowances, drugs and medical supplies, structures, Personnel and the least costly item being equipment.

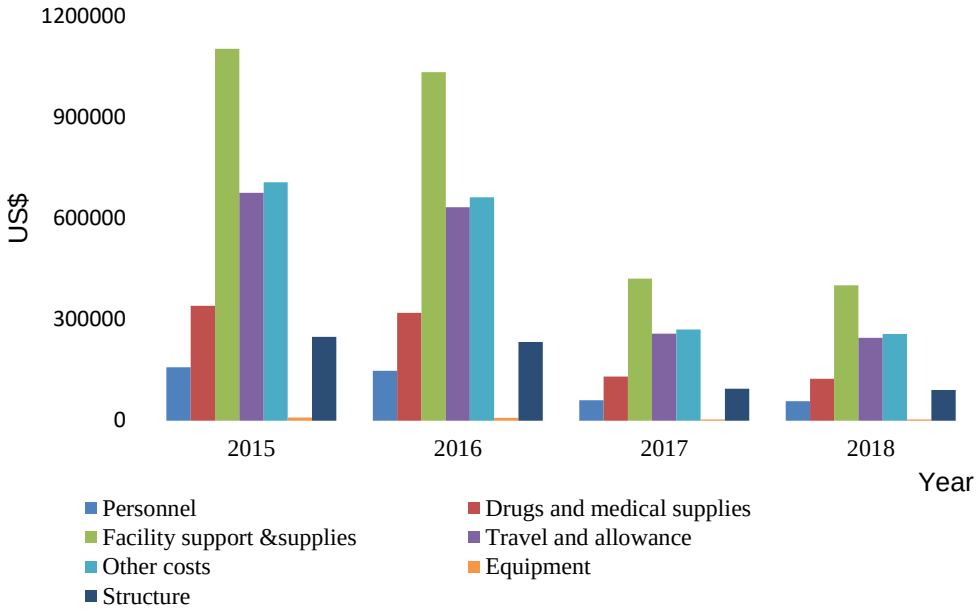

Figure 2: Trend of Cholera treatment costs by cost variable for four years.

Estimated cost according to disease severity and age group of patient

Figure 3 shows disaggregated average treatment cost annually for four (4) years per disease severity per age group. Figures shows that group aged 5-14 years with Mild- moderate dehydration accounted more for the annual treatment cost incurred each year which was US$ 674,927.9 for 2015 and US$ 245578.4 for 2018. This was followed by group aged 15+ years with severe dehydration as US$ 629504.8 for 2015 and US$ 229085.5 in 2018. However, group aged under 5 years with severe dehydration extended stay showed to cost less than all other group with the cost of US$ 136266.37 in 2015 and US$ 49585.37 in 2018.

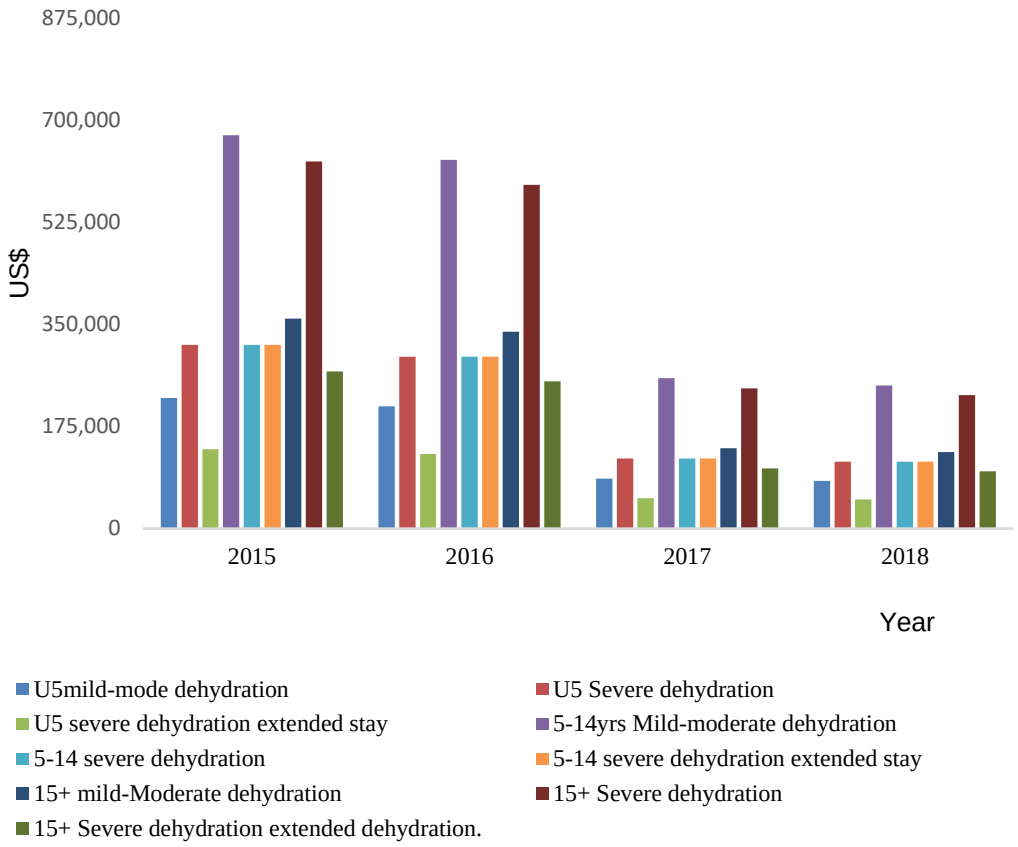

Figure 3: Treatment costs per age group and Cholera severity for four years.

DISCUSSION

Key findings

This study estimated the costs of treating Cholera patient incurred by the public health system in Tanzania. This study, we found that on average, public health care system incurred US$ 106.75 in the treatment of one patient of Cholera for one Cholera episode. About 32,528 cases of Cholera were reported to the Ministry of Health Tanzania and WHO for four (4) years from 215 to 2018 showed minor discrepancies but with the estimated conservative sensitivities reported from some reputable study by Mohamed Ali et al. Cholera Sensitivity case range of 78,100 to 84,937 estimated conservative cases of cholera for Tanzania for four years from 2015 to 2018 resulted in a total economic loss of US$ 8,702,099.87 (Sensitivity cost range US$ 8,337,175 – US$ 9,067,024.75). Cholera treatment cost incurred by the public health system revealed to account for approximated at US$ 3.24 million, US$ 3.04 million, US$ 1.24 million and US$ 1.18 million for 2015, 2016, 2017 and 2018 respectively. In addition, our study found that Cholera treatment cost incurred by our public health facility that we used as focal study site was about US$ 7,676.22. This study found that the cost for Cholera treatment decreased progressively from 2015 to 2018 due to the fact that the number of cases reported decreased. Moreover, our study found that the main driver of treatment costs of cholera in this study is facility support supplies which accounted for 34.0% (US$ 36.32) of the all treatment cost incurred by the public health care system, this was followed by other costs by 21.8% (US$ 1,676.10) and training and allowances by 20.9% (US$ 1,602.08). We are not surprised that drugs and

medical supplies were the smallest driver, accounting for less than 10.5% (US$ 807.78) incurred by the health facility for treating the disease because treatment in all cases is mostly rehydration and single antibiotic and also shorter hospital stay (3-4 days).

The finding from our study that Cholera treatment cost incurred by public health care system per patient to be as high as US$ 106.75 is contrary to other studies results which were reported previously including US$ 61 in Zanzibar, Tanzania, in 2012 (Schaetti et al., 2012) and between US$ 17.6–28.4 in Matlab (Bangladesh), Kolkata (India), Beira in (Mozambique), and North Jakarta (Indonesia) (Sarker et al., 2013). Approximately 34.21% of all treatment costs were due to facility support and supplies and in our study we found facility support and supplies to be the driver for the treatment costs. However, we were not surprised as one could think drugs and medical supplies could be a driver factor for treatment cost but instead we found not even among top four of the leading drivers of Cholera treatment drivers. This is because Cholera disease is principally treated by Oral rehydration fluids and a single dose of antibiotic and duration of hospitalization is as short as 3 to 4 days only.

This study has numerous assumptions and therefore the accuracy of the Cholera treatment estimates based on the plausibility of the assumptions that WHO Cholera treatment guideline was used consistently during management of Cholera cases. Therefore, this study results interpretation should be tempered with the limitations highlighted beneath. We should emphasize that the purpose of this study on the estimate of Cholera treatment burden to the public health care system is not to guide policy decisions by relying solely on the figures

of the study results but rather this stool will be a tool to raise awareness among policy-makers and the public in general about the negative economic impact of cholera. Moreover, it is worth mentioning that many other diarrheal, respiratory, and vector borne diseases exert even a greater toll of mortality than that of cholera.

Limitations

This study has a myriad number of limitations. First, our study did not assess direct costs incurred by the household such as providing food to the patient, transport cost for visiting patient hospitalized, costs of hotels for relatives/caregiver. This costs may have contributed to underestimating the actual cost of treating patient with Cholera disease in this study. Second, because cholera outbreaks are largely unpredictable, health care personnel are not hired specifically to deal with this illness but rather are pulled from other duties and from other facilities. This, in turn, has a cascading effect on the health system especially on delivery of health services to other non-Cholera illnesses, this effect was not explored as it was not in the scope of this study but could have also led to underestimation of treatment cost. Third, this study did not estimate the indirect costs associated with Cholera outbreak, these indirect costs include costs associated with loss of tourism due to fear of the cholera outbreak, closure of businesses and economic opportunities for affected communities, closure of schools and the days lost thereafter. Fourth, this study did not account for mortality cost associated with DALYs calculations and therefore this could have led to underestimation of impact of Cholera to the public health system. Fifth, data of our study were collected retrospectively for four years, data collected were however showing significant discrepancies between those from Ministry of Health Tanzania, those reported in WHO and the estimated cholera cases from study done by Mohamed Ali et al. This myriad differences in these sources was the reason to select Sensitivity ranges established by study by Mohamed Ali et al to estimate the economic impact of Cholera in Tanzania health care system. Sixth,

our study did not include the estimation of values of preexisting health facility building such as wards which were assigned for management of Cholera cases during the outbreak. This exclusion could have dramatically increased the cost incurred in the management of Cholera cases than what have been found in our study. The study results revealed to be contrary to other studies reported previously and the partial reason for this might be due to poor reliability of data which showed major discrepancies.

Strengths

The fact that our study has vast limitations as pointed out above, this study carries a number of strengths. Most of the literature review we found on economic impact of Cholera come from Asian countries and only very few published literatures are from Africa and only one study was conducted in Zanzibar archipelago, Tanzania. Cholera disease is endemic in Tanzania and in most Sub Saharan Africa, hence there is a need for more studies of this nature to be conducted in Sub Saharan Africa and Tanzania in particular to raise awareness to policy-makers and public in general about the impact of the disease to the economy.

The high estimated cost of US$ 106.75 for treatment of a single Cholera patient revealed from this study point out clearly the need for further extensive research in Tanzania to ascertain the burden of Cholera that is inflicting in the country's economy. This study therefore may serve as a catalyst for setting up comprehensive study on the burden of Cholera outbreaks on the general economy of the country and subsequent shift of the paradigm of intervention on the field which is pragmatic oriented.

CONCLUSION

Our findings revealed that Cholera impact in Tanzania stands high at about US$ 106.75 for treatment of a single Cholera patient when comparing with other studies which found to be US$ 17.6-28.4 in Matlab (Bangladesh), Kolkata (India), Beira (Mozambique) and US$ 61 in Zanzibar. The treatment cost for the whole Country revealed to decrease on annual basis and ranged around US$ 3.24 million to US$ 1.18 million from 2015 to 2018 respectively.

This study is important for policy and Pubic health decision-makers in Tanzania as it creates awareness about the alarming Cholera impact on the Country's economy. This study entails the urgent need for improved Cholera surveillance, quality data collection and reporting and the country need for paradigm shift in combating Cholera by investing significantly on basic sanitation and hygiene, improve access to clean and safe water and the use of oral Cholera vaccine in cholera hot spots to eliminate the disease. The study also offers a light about the need for further future overarching research in the country to ascertain the impact of Cholera to the Country's economy.

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